Space Station Construction Activity

The International Space Station: A dream… a vision… a reality.

Introduction
The International Space Station (ISS) is an unparalleled international, scientific, and technological cooperative venture that is opening a new era of human space exploration and research that will provide benefits to people on Earth. The ISS, the largest spacecraft in history, will be launched on more than 40 launches using three different launch vehicles. Comprising six different laboratories, the ISS will enable unprecedented advances in biological, medical, materials, and industrial research.

Phase II of the ISS program began after the successful completion of the Shuttle-*Mir* program (Phase I). Phase II of ISS development consists of 10 separate flights. These flights, the focus of this poster, begin the construction phase and are the foundation for the ISS. In the activity, students will design and build their own space station. This will provide them with the foundation so their vision of a space station can become a reality.

Flight Background Information
The A stands for American. The R stands for Russian. The following flights are listed in the order of launch.

Flight 1A/R (Russian Proton Rocket)
The first element launched was the Control Module named *Zarya*, the Russian word for "sunrise." *Zarya* provides propulsion control capability and power through the early assembly stage. It also provides fuel storage and rendezvous and docking capability to the Service Module. The 18,182-kilogram pressurized spacecraft was launched on a Russian Proton rocket. As assembly continues, *Zarya* will provide orbital control, communications, and power for the U.S.-built Node 1, *Unity*. During this period, *Zarya* will control the motion and maintain the altitude of the Space Station's orbit. It will also generate and distribute electrical power and provide ground communications. In the later stages of ISS assembly, *Zarya* will primarily provide storage capacity. It will be used throughout the life of the Space Station.

Flight 2A (Shuttle Flight)
On flight 2A, *Unity* and Pressurized Mating Adapters (PMA) 1 and 2 were launched. The PMA-1 connects the U.S. and Russian elements. The PMA-2 provides a Shuttle docking location. *Unity*'s six ports provide connecting points for *Zarya*, as well as the Z1 truss, airlock, cupola, Node 2, and the Multi-Purpose Logistics Module, to be delivered later. *Unity* is a connecting passageway to the living and working areas of the ISS—the U.S. Habitation and Laboratory Modules—and airlock. It is the first major U.S.-built component of the ISS. It contains more than 50,000 mechanical items, 216 lines to carry fluids and gases, and 121 internal and external electrical cables using 9.7 kilometers of wire.

Flight 1R (Russian Proton Rocket)
Flight 1R will launch the Russian Service Module, the primary Russian element. The Service Module will provide the Environmental Control and Life Support System elements and will be the primary docking port for the Progress resupply vehicles. It will also provide propulsive attitude control and reboost capabilities, early Space Station living quarters, electrical power distribution, the data processing system, the flight control system, and communications. Although many of these systems will be supplemented or replaced by later U.S. ISS components, the Service Module will always remain the structural and functional center of the Russian segment of the ISS.

Flight 2A.1 (Shuttle Flight)
The flight element for 2A.1 is the Spacehab Logistics Double Module. The purpose of the double spacehab flight is to provide a logistics flight for the early assembly missions. It will carry equipment to further outfit the Service Module and equipment that can be off-loaded from the early U.S. assembly flights. The Double Module has the capacity to hold up to 4,536 kilograms as well as the ability to accommodate powered payloads.

Flight 3A (Shuttle Flight)
Flight 3A will deliver the Integrated Truss Structure (ITS) Z1. The Z1 truss will be used as a mounting location for the P6 Truss Segment and Photovoltaic (solar array) Module. This Photovoltaic Module will provide power for the early science that will be done on the ISS. Also being delivered on this flight will be the third Pressurized Mating Adapter and the Control Moment Gyros (these will provide nonpropulsive attitude control). In addition, the Ku-band communications system will be installed on this flight (and later activated on flight 6A). This system provides video capabilities to support ISS scientific research and television transmissions.

From The International Space Station: A Dream…A Vision…A Reality,
EW-1998-09-130-HQ

Flight 2R (Russian Soyuz Rocket)
This launch will establish the first ISS three-person crew, or Expedition I. The Commander will be a U.S. Astronaut and the other two crew members will be Russian Cosmonauts. The Soyuz vehicle will provide crew return capability without the Shuttle present. The first crew will spend 5 months on the ISS.

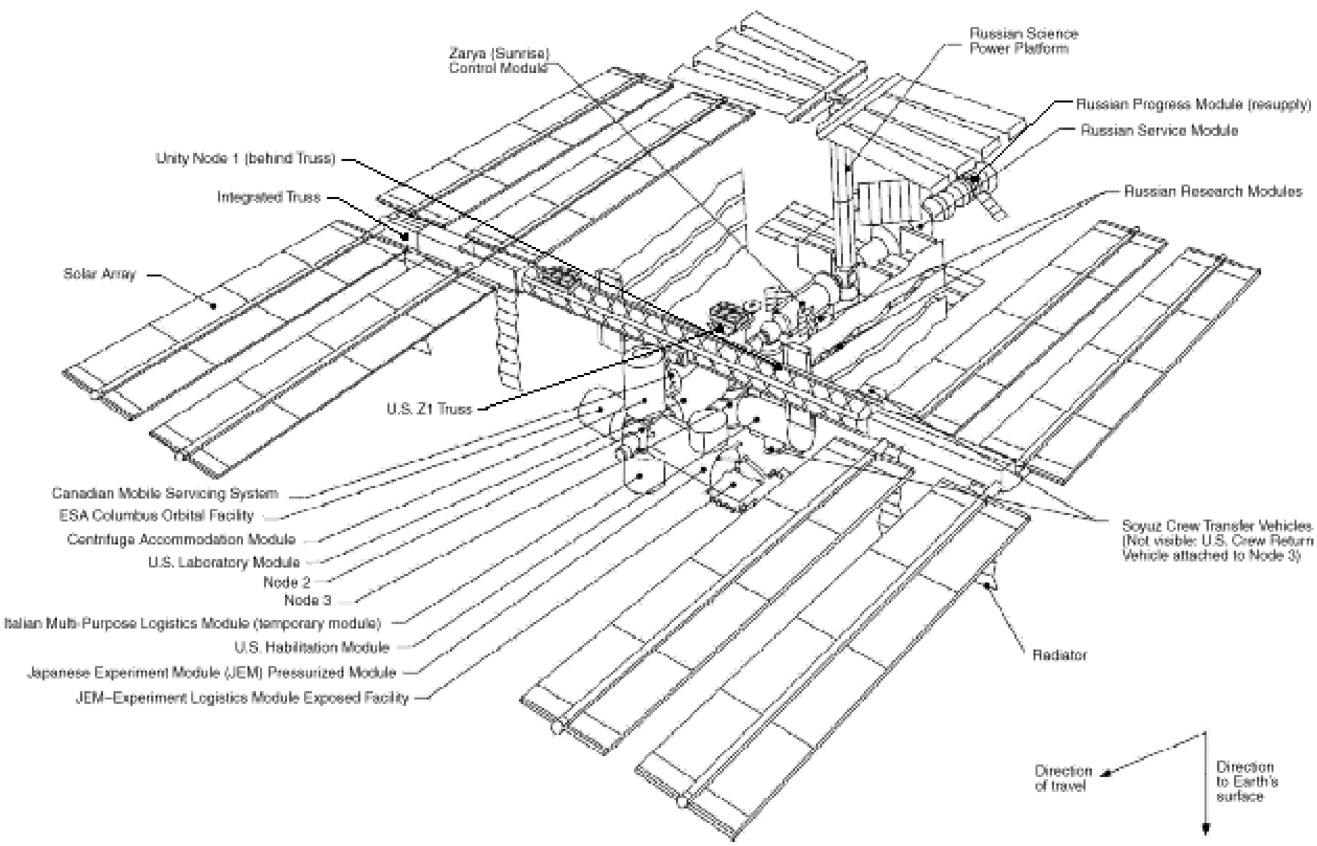
Flight 4A (Shuttle Flight)
The completion of this flight reflects the temporary installation and activation of the P6 truss segment. The P6 Photovoltaic Module is the first of four U.S. solar-based power sources. It will be moved and permanently attached to the P5 truss after flight 13A. Two Photovoltaic Thermal Control System radiators will provide early active thermal control. Also, the S-band communications system will be activated. This will provide radio communications on a specific frequency and the capability of transferring data.

Flight 5A (Shuttle Flight)
Flight 5A will deliver the U.S. Laboratory Module. This lab will provide a shirt-sleeve environment for research, technology development, and repairs by the on-orbit crew. The U.S. Laboratory will distribute several systems, including Life Support, Electrical Power, Command and Data Handling, Thermal Control, Communications, and Flight Crew Systems. There will be a total of 24 racks for experiments in the U.S. Laboratory.

Flight 6A (Shuttle Flight)
This flight will outfit the U.S. Laboratory. Also during this flight a UHF antenna will be provided that will allow space-to-space communications capability for the U.S.-based Extravehicular Activity (EVA), also known as a *spacewalk*. In addition, the Canadian Space Station Remote Manipulating System will be delivered and activated. This is the next generation in robotic arms, and it will be bigger, better, and smarter than the Space Shuttle's robotic arm. It is 17 meters long when fully extended and has seven motorized joints. The arm is capable of handling large payloads and assisting with docking the Space Shuttle. It is self-relocatable so that it can be attached to complementary ports spread throughout the Space Station's exterior surfaces.

Flight 7A (Shuttle Flight)
The Joint Airlock will be delivered on this flight. It will provide ISS-based EVA capability for both U.S. and Russian spacesuits. The airlock will be attached to *Unity*. It has a total pressurized volume of 27 cubic meters. Also delivered on this flight will be the High Pressure Gas Assembly, which augments the Service Module gas resupply system. Each bottle is installed separately and capable of recharge on orbit (limited to oxygen).

Access the Space Station Home Page to learn about Phase III assembly and general Space Station information: **http://spaceflight.nasa.gov**



From The International Space Station: A Dream…A Vision…A Reality, EW-1998-09-130-HQ

Space Station Construction Activity

Adapted from an activity provided by Space Center Houston.

Topic: Construction of a Space Station

Objective: The students will create a model of the International Space Station given a set of materials and parameters.

Science Standards
Science as Inquiry
Science and Technology: Abilities of Technological Design
History and Nature of Science: Science as a Human Endeavor, Nature of Science

Mathematical Standards

Problem Solving	Number Systems and Number Theory
Communicating	Computation and Estimation
Reasoning	Measurement
Mathematical Connections	

Universals of Technology
Designing and developing technological systems
Determining and controlling the behavior of technological systems
Linkages
Physical systems

Materials Needed

Plastic kitchen wrap	Square centimeter paper
Craft sticks	Individual serving cereal boxes
Aluminum foil	Flexible straws
Small buttons	Balances
Soft drink cans	Rulers
Toothpicks	Scissors
Cardboard tubes (toilet paper size)	Glue
Styrofoam food trays	Masking tape

Correlation of Materials to Space Station Components
Plastic kitchen wrap = Photovoltaic (PV) arrays
Craft sticks = Support structure for Photovoltaic (PV) arrays and thermal radiators
Aluminum foil = Thermal radiators
Cylindrical cans = Modules 1 (habitation) and 2 (laboratory)
Cardboard tubes (cut into thirds) = Docking port
Styrofoam food trays (cut into 4-cm wide strips) = Truss segments
Individual serving size cereal boxes = Module 3 (core)
Buttons = Control jets
Flexible straws = Robotic arm
Toothpicks = Miscellaneous decorations, supports, etc.

Procedure

Explain to the students that NASA engineers need their help. They need new ideas for the International Space Station.

1. Collect the necessary materials or instruct students to bring them from home. Display a model of the "old" International Space Station (this poster will do) as you discuss each individual component and its function: Module 1—habitation, Module 2—laboratory, Module 3—core (Resource Node), PV arrays, thermal radiators, docking port, control jets, and robotic arm.

2. Show the constraints that must be followed for the design:
(a) One hundred square centimeters of PV array will support the electrical needs of 500 cm^3 of module volume.
(b) All modules must be connected to at least one other module.
(c) Seventy-five square centimeters of thermal radiators will support the colling needs of 500 cm^3 of module volume.
(d) The length of the truss can not be longer than 50 cm.
(e) The control jets must be positioned so that they will not fire on any component of the Space Station and can move it in any direction.

Space Station Construction Activity *Continued*

(f) The docking module should be positioned so that there is a clear, straight path to it for the orbiter to dock.
(g) The robotic arm should be placed to maximize the number of components that it can reach.

3. Depending on the amount of freedom you think your class can handle or their mathematical background, go through the procedure pages with them or allow them to work through the pages with their groups, assigning different roles for each group member to accomplish.

4. To simplify the determination of the volume of the soft drink cans, use the can's maximum diameter for calculations.

5. Have the groups construct their Space Station.

We want you to build a new model of the International Space Station and present it to the class for approval. Of course, because of some limitations we have on size and weight of the Space Station, we do have a few requirements for you. Please assist us in creating a model that follows the guidelines.

Modules Design (student section)

1. Weigh Module 1 (habitation) and record. Mod.1 = ________________grams

2. Take can (circular face down) and trace the cross-sectional area on paper.

3. Estimate the center point of the circle.

4. Find the diameter (distance across the circle). d = ________________cm

5. Find the radius (distance from center point to the edge). r = ______________cm

6. Find the area of the cross section. The area is equal to π (3.14) times the radius. The formula is $A = \pi \times r^2$

Area = π x ______________ x ______________ = _______cm^2
radius radius Area

7. Find the height of the can. Height = ____________________cm

8. Multiply the area from number 6 above with the height of the can in number 7 to obtain the volume of Module 1. The formula is $V = \pi r^2 \times h$.

______________cm^2 x ______________cm = _____cm^3
Area from 6 Height from 7 Volume of can

Using the same formulas, find the volume of the other can (Module 2) — the Laboratory Module. Volume of Module 2 = __________cm^3

9. Weigh Module 3 (core) and record. Module 3 = ________________grams

10. Measure Module 3. Length = ______________cm Height = _______cm
Width = ______________cm

Now that you have the volume for Modules 1 and 2, obtain the volume for Module 3—the Core Module. The Core Module is where the brains of the Space Station exists. In your model, a box (rectangular prism) has been used to represent the core. The formula for finding the volume of a rectangular prism is

V = ______________ x ______________ x ______________ = _____cm^3
Length Width Height

11. The next step is to find the sum of the weight for all of the modules and the sum of the volume of Modules 1, 2, and 3.

Weight-Module 1	__________	grams
Weight-Module 2	__________	grams
Weight-Module 3	__________	grams
Total weight of modules	__________	grams
Volume-Module 1	__________	cm^3
Volume-Module 2	__________	cm^3
Volume-Module 3	__________	cm^3
Total volume of modules	__________	cm^3

From The International Space Station: A Dream…A Vision…A Reality, EW-1998-09-130-HQ

Space Station Construction Activity *Continued*

PV Array Design (student section)

1. Total volume of Modules 1, 2, and 3 __________ cm^3.

2. One hundred cm^2 of PV array will support the electrical needs of a module with a volume of 500 cm^3. How many square centimeters of PV array will be needed to support the entire Space Station?

   Total area of PV modules __________ cm^2.

3. Construct a PV array as shown in the illustration.

4. Measure the area of the cellophane used in your array.

   __________ x __________ = __________ cm^2
   length width area

5. How many arrays will be needed to support the entire Space Station? Divide your answer for number 2 by your answer for number 4.

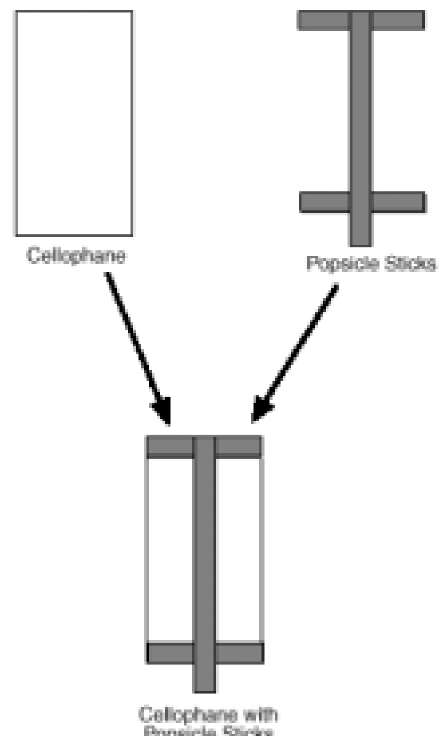
   __________ cm^2 / __________ cm^2 = __________
   answer 2 answer 4 # of arrays

6. Construct the number of arrays you will need.

7. Weigh your arrays and record the total mass in grams.

   Total mass of the arrays __________ g.

Set them aside when completed.



Space Station Construction Activity *Continued*

Thermal Radiator Design (student section)

The thermal radiators are used to help cool the Space Station. There are some restrictions for your design.

1. Total volume of Modules 1, 2, and 3 __________ cm^3.

2. Seventy-five cm^2 of thermal radiators can support the cooling needs of a module with a volume of 500 cm^3. How many square centimeters of thermal radiators will be needed to support the entire Space Station?

   Total area of thermal radiators __________ cm^2.

3. Construct a thermal radiator as shown in the illustration.

4. Measure the area of the aluminum foil used in your thermal radiator.

   __________ x __________ = __________ cm^2
   length width area

5. How many thermal radiators will be needed to support the entire Space Station? Divide your answer for number 2 by your answer for number 4.

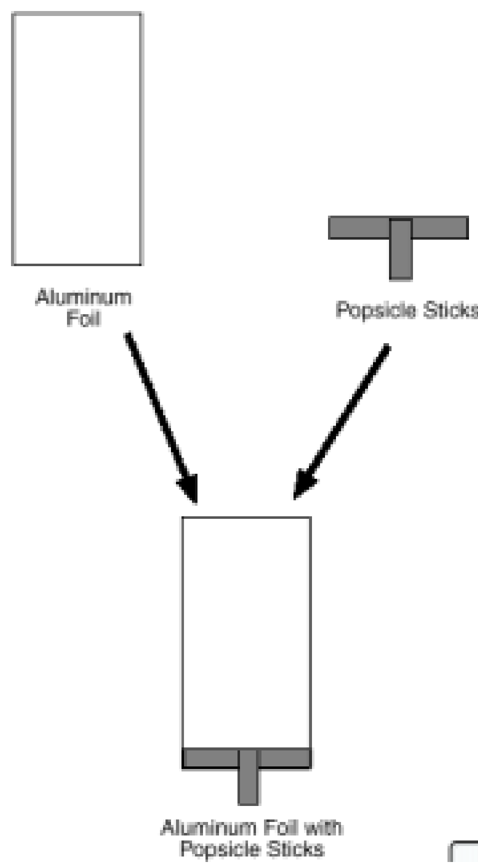
   __________ cm^2 / __________ cm^2 = __________
   answer 2 answer 4 # of radiators

6. Construct the number of thermal radiators you will need.

7. Weigh your thermal radiators and record the total mass in grams.

8. Total mass of the thermal radiators __________ g.

When completed, set them aside.



From The International Space Station: A Dream…A Vision…A Reality, EW-1998-09-130-HQ

Final Design (student section)

1. The first task is to decide where all of the components of the Space Station will be in your model. Using centimeter paper, make a sketch of each part and where you would like to put it. Design the truss according to where the PV arrays and thermal radiators will be. Remember the truss requirements.

2. Construct a truss. Take the food trays and, if necessary, cut them to meet your specifications. Connect them together. Popsicle sticks can be used to help support connections. The truss does not need to be in one line, but according to the constraints, it cannot be longer then 50 cm.

3. Glue the modules together and connect them to the truss in the proper position.

4. Connect the PV arrays in their proper position.

5. Place the thermal radiators in their proper position.

6. Put the docking port (toilet paper roll) on one of the modules.

7. Glue the control jets (buttons) on any of the Space Station components except the radiators or PV arrays. Remember to check the requirements.

8. Place the robotic arm (flexible straw) on the Space Station. Do not put it on the PV arrays or radiators. Maximize the distance it can reach on the other parts of the Space Station.

Weight Calculations (student section)

1. Find the total weight of your Space Station.

2. First, take the sum of the weights for the modules, PV arrays, thermal radiators, and truss structure:

Weight	Modules		_______________grams
	+	PV arrays	_______________grams
	+	Thermal Radiators	_______________grams
	+	Truss Segments	_______________grams
Weight =			_______________grams

Getting a total weight for the International Space Station will be done this way. It will be impossible to get a total weight of the Space Station at one time. The International Space Station will never be assembled here on Earth. It will be assembled on orbit.

3. If possible, weigh your entire model. Use this figure to compare the accuracy of weighing individual pieces as compared to the entire Space Station.

   Space Station Weight = _______________grams

4. How close was the weight in number 2 to the weight in number 3? Subtract number 2 from number 3.

Space Station Weight (number 3)		_______________grams
−	Weight (number 2)	_______________grams
	Difference =	_______________grams

Discussion
1. Why are there restrictions on the individual components of the Space Station?
2. Why is it important for the truss not to be over 50 cm?
3. Why do the control jets need to be pointed away from the Space Station components?
4. Why did you choose the design you did?

Extensions
1. Have the students write instructions for building a Space Station.
2. Design a campaign for advertising the Space Station. Use video and/or print products.
3. Invite parents, faculty, and the local press to a Space Station expo. The completed Space Stations and the advertising campaigns can be displayed. Group members can discuss their designs.

Assessment
Students will comply with all set parameters and complete the needed math functions in order to meet those guidelines.

For more information about the International Space Station, please visit http://spaceflight.nasa.gov

From The International Space Station: A Dream…A Vision…A Reality,
EW-1998-09-130-HQ